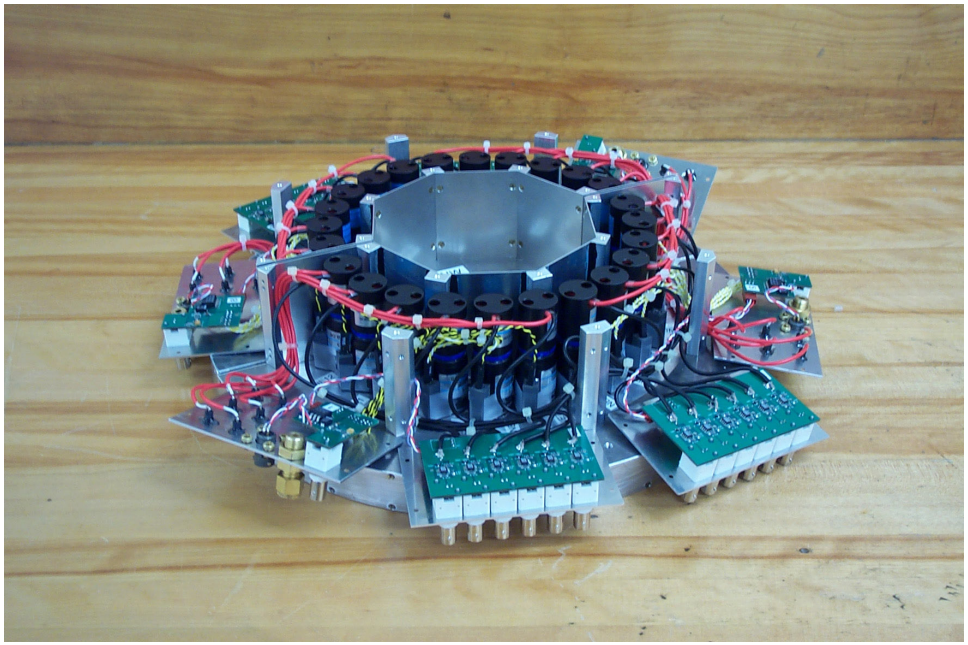
Update on D0 Luminosity

Outline

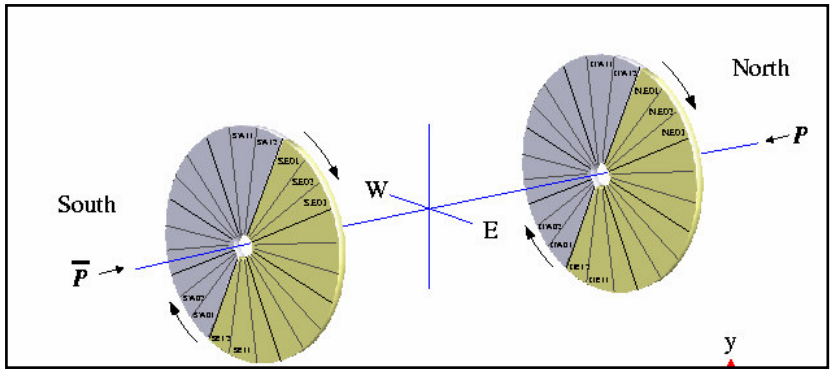
- Early Run II progress
- Year 2004 developments (see Brendan's plenary talk for details)
- Concluding remarks



D0 Luminosity 2001-2003

Principle of D0 luminosity measurement is simple

- Count number of crossings with > 0 interactions
  - Two scintillation counters arrays mounted on both sides of interaction region
- Assuming Puasson statistics determine average number of interactions per crossing
  - Then calculate luminosity using known values for inelastic, etc. cross section and detection efficiency



$$\mathcal{L} = -\frac{f}{\sigma} \ln\left(1 - P(n > 0)\right).$$

There are some technical complications not critical for the discussion

New Run II detector, but (old) Run I electronics
Used Run I efficiencies numbers as well
Between 2001 and 2003 the system was running stable
Less than ~1% changes over 3 years for muon yield at $L \sim 15 \cdot 10^{30}$ $cm^{-2}sec^{-1}$
Error on D0 luminosity measurement was ~10%
CDF luminosity was always ~5% above D0, but it was "within errors"
We saw CDF/D0 luminosity ratio instabilities → CDF luminosity counters calibration

Early 2004 Developments

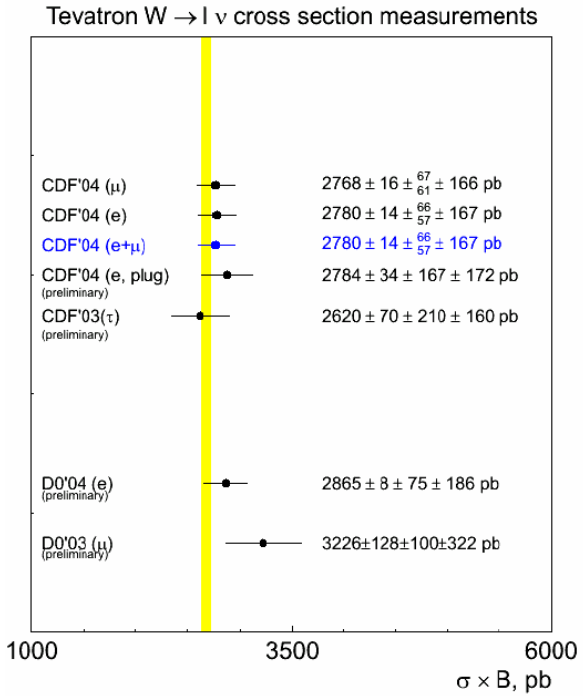
- In January 2004 new D0 luminosity constant has been introduced
  - Run II efficiency calculations, halo, total cross section, etc.
    - Same value for cross sections used by D0 and CDF
    - A few % decrease in measured D0 L at low luminosity, about the same at L>$30 \cdot 10^{30}$
    - Error on D0 luminosity went down to 6.5%
- Comparison of W/Z cross sections
  - Provides absolute normalization

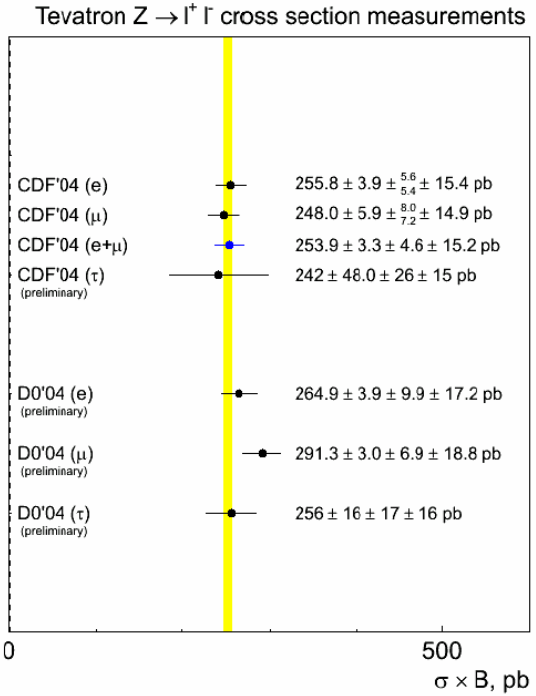
CDF/D0 Ratios
(no luminosity errors)

W→ eν: 0.97+-0.03
Z→ ee: 0.97+-0.03
(Z→ μμ: 0.85+-0.04)

D0 luminosity
(for the same number of W/Z's)
~3%+-3% lower then CDF

No clear issues

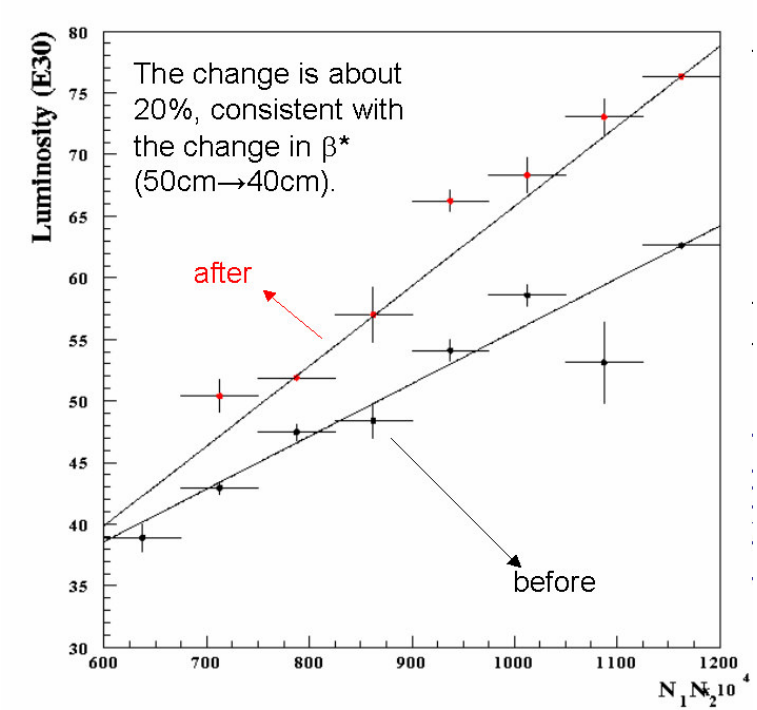


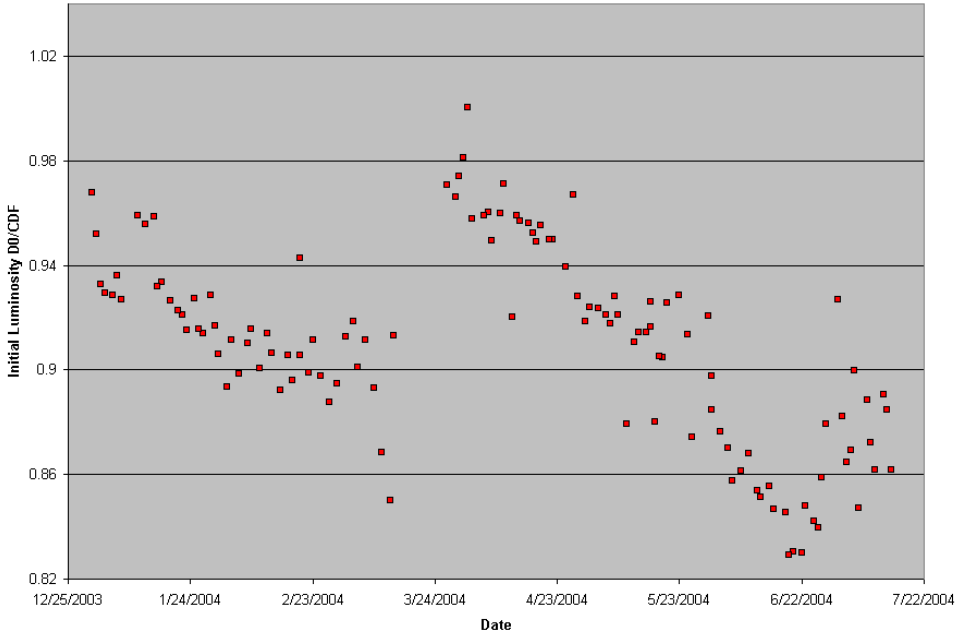


Most of data collected at L below ~$30 \cdot 10^{30}$

Accelerator Issues

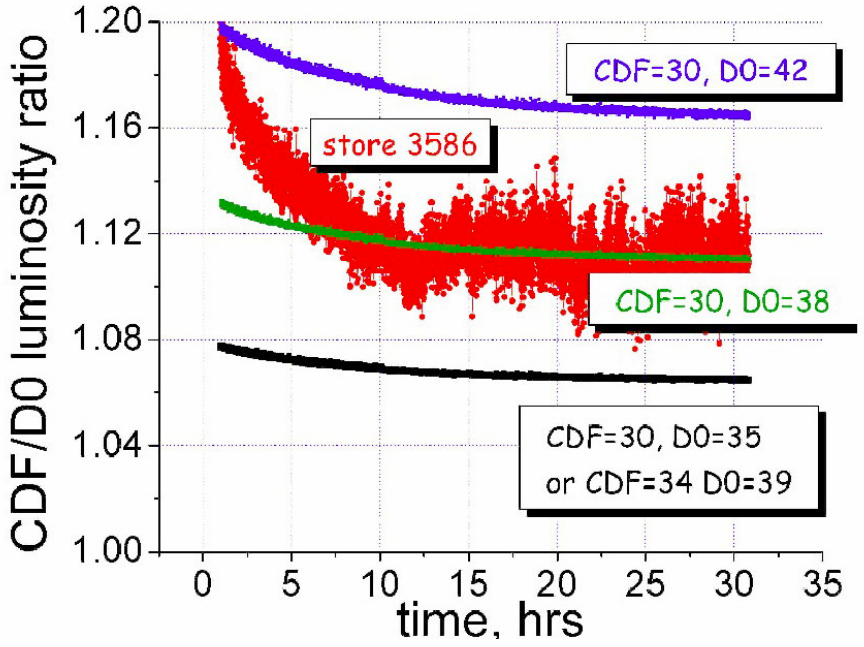
- Accelerator Division and D0 studies
  - Actual luminosity was below what you expect from number of particles in the Tevatron by ~30% assuming β* of ~35cm
  - D0 helped in understanding this issue by measuring β* of ~50cm
- March 2004 shutdown
  - Accelerator Division adjusted CDF/D0 interaction regions optics
  - Both experiments saw substantial luminosity increase (per number of p and pbar's in Tevatron)
  - CDF/D0 luminosity ratio jumped to ~1.0 for a few stores, but…
    - Corrections to CDF crossing angle lowered this ratio back to ~0.9 at low L

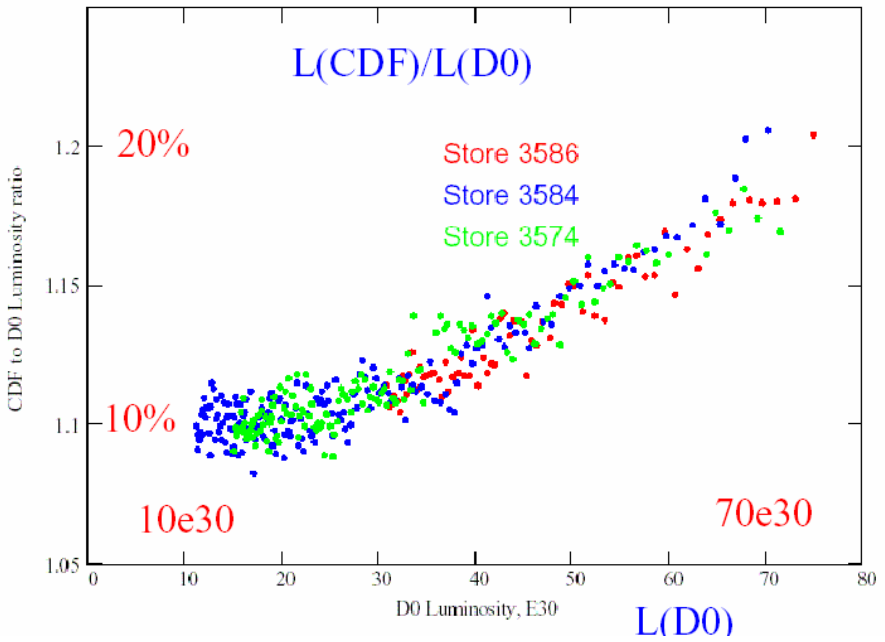




Summer 2004 Saga

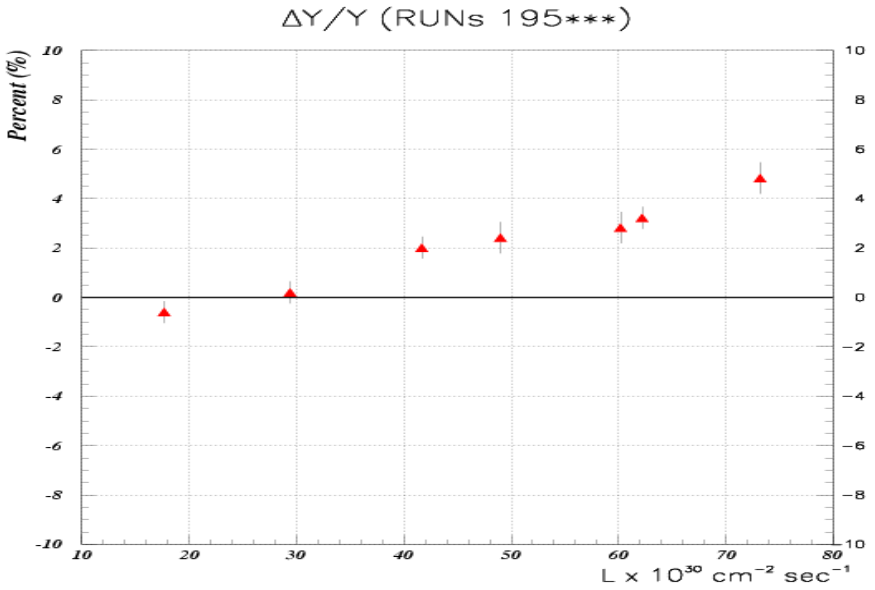
- After March 2004 shutdown Tevatron luminosity was going up and up
  - At the same time D0/CDF ratio (at the beginning of stores) was going down
    - Reaching ~0.8 for some stores in June/July
      - Alarmed many at D0
- AD is puzzled as it is hard to explain "fast" drop in luminosity ratio at the beginning of stores (at high L)
  - AD was not eager to work on this issue short term

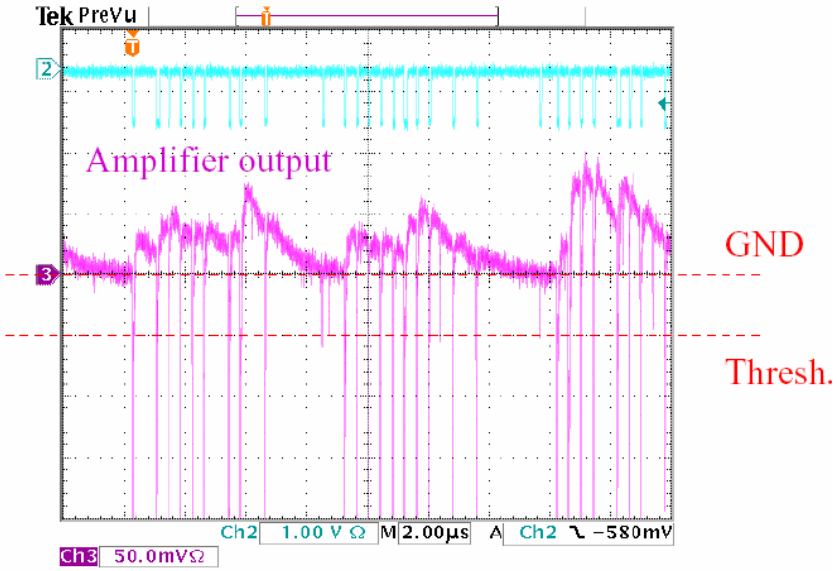




D0 Cross Checks of L Measurement

- While we have been reasonably confident about operation of luminosity system at low luminosity running above ~$50 \cdot 10^{30}$ was a new region
  - # of verticies vs L
  - Muon yields vs L
- Preliminary results supported correct D0 luminosity measurement, but… after cross checks
  - # of verticies
    - Incorrect assumption that vertex reconstruction efficiency is flat vs luminosity
  - Muon yield
    - Simple luminosity accounting error
  - Direct observation of issues with D0 luminosity electronics



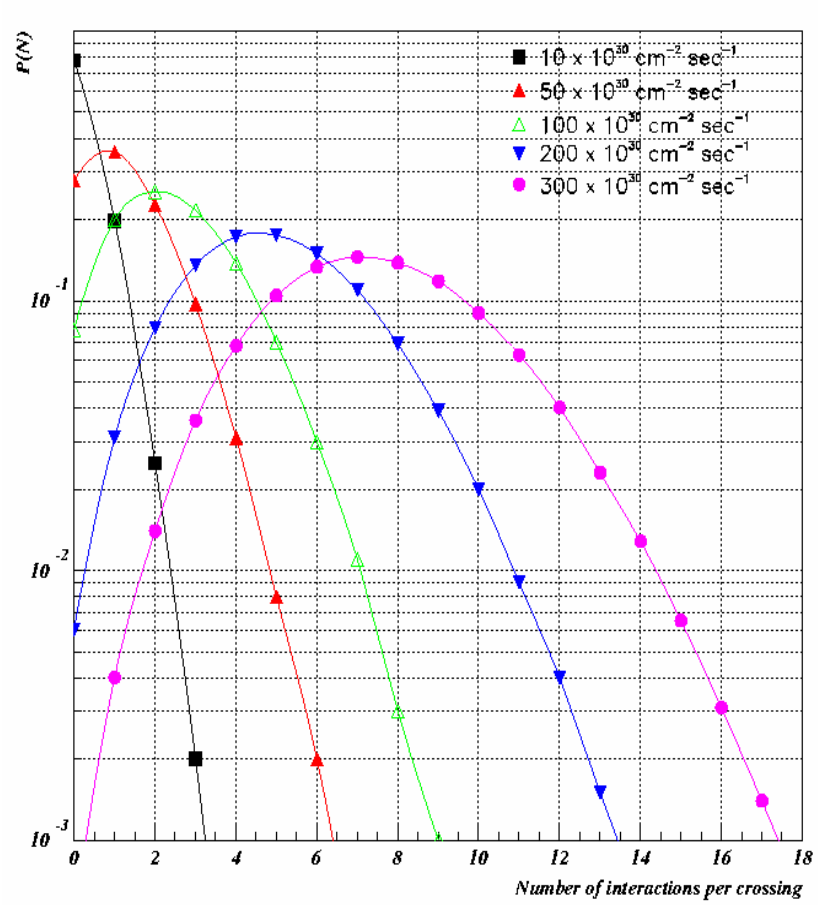


Where Are We Now?

- Most (if not all) of the "fast change" of D0/CDF ratio can be explained by D0 luminosity mis-measurement at high luminosity
- At low luminosity CDF luminosity is still higher then D0 by ~5-10%
  - Do we really have less collisions or one experiment is mis-measuring luminosity?
  - W/Z cross sections
    - D0 measured luminosity is 3%+-3% below CDF (or CDF too high)
  - Beam size studies
    - D0 interaction region might still have some imperfections
  - We are talking about "a few %" effect with "a few%" error
    - Not 20%!
- Effect on physics up to August 2004 shutdown
  - Small amount of luminosity integrated above $50 \cdot 10^{30}$
    - ~20% of data x ~5% effect → ~1% effect
    - Even lower for prescaled triggers
    - Much less then D0 luminosity measurement error of 6.5%

For most D0 studies (cross sections) this issue is not critical

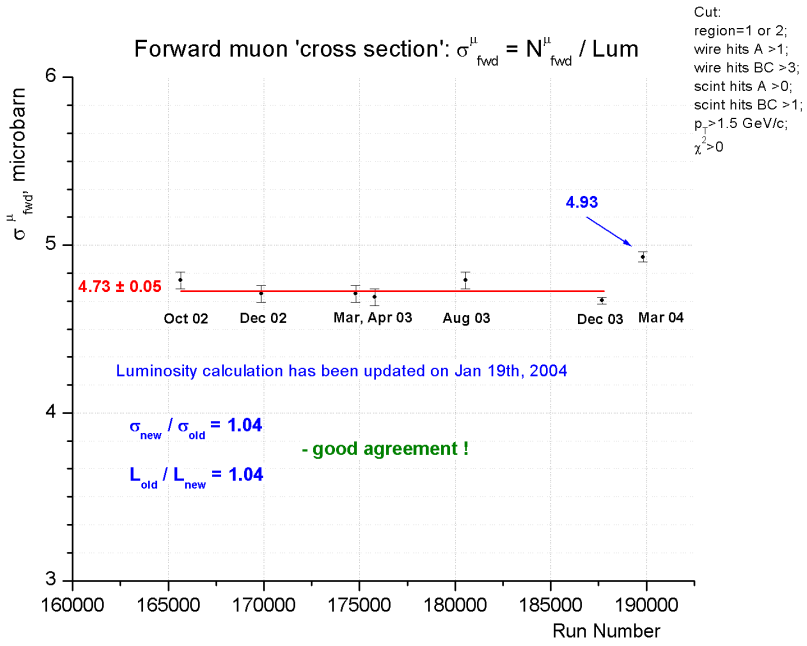
Recent issues are just tip of the Iceberg: LHC at D0?



- Very large number of interactions per crossing is coming
  - Many sub-systems will work poorly (not only D0reco)
    - Not been designed for such conditions: 132ns operation suppose to start at $80 \cdot 10^{30}$
    - Not too many "0" for luminosity counting
- 132ns is gone… but luminosity leveling is critical
  - Uniform pbar bunches (factor of ~2 different currently)
  - Shorter stores (lower peak higher final luminosity)
  - β^* changes during store
- Have to work with the Lab and Accelerator Division

Back-up Slides

- Monitoring muon system stability over last ~3 years using muon yields:
  - Yield = N_{muons}/Ldt
  - 1% stability many runs collected – most at L in the 10-20E30 region



Decided to use similar technic for yield vs L studies,
after discovery of puzzling features in CDF/D0 L ratio last spring